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Development of Australian portion size photographs to enhance self-administered online dietary assessments for adults

Yasmine Probst
University of Wollongong, yasmine@uow.edu.au

Holley-Anne Jones
University of Wollongong, holley@uow.edu.au

Gemma Sampson
University of Wollongong, gs412@uow.edu.au

Kimberley Smith
University of Wollongong, kms882@uow.edu.au

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Abstract

Aim: Technology is being used increasingly for dietary assessment, to streamline and improve the efficiency. These technologies allow for the inclusion of visual food portion images within the assessments rather than in addition to them as previously required. This paper describes the methodology for creating these food portion images using an online dietary assessment website (DietAdvice) as an example technology. The images include country-specific Australian food items, not previously available.

Methods: Foods contained in the DietAdvice website were assessed to determine the number requiring food portion images. Preparation methods, recipes and portion sizes were determined for the foods, which varied from single foods through to cooked dishes and beverages. Foods were photographed by a professional photographer against a white background on a standard dinner plate or bowl with a standard of reference in each frame.

Results: Approximately 200 food items required images, with varying portion sizes ranging from two to eight images per food item. Six hundred and thirty-one photographs were taken. Food such as ice-cream, burritos and fruit needed to be photographed quickly to prevent deterioration and ensure a quality real-to-life photographs.

Conclusion: The art of photographing food portions itself is a difficult task. Inappropriate angles or lighting can make the food appear larger or smaller than it actually is. Timing is critical as the food can melt, wilt, collapse or discolour if the photo is not taken promptly. Clear labelling and a standard of reference for all photographs was necessary. The developed food portion images will allow users of the DietAdvice website to estimate portion sizes more accurately than text-based sizes alone, although validation is required.

Disciplines

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Development of Australian portion size photographs to enhance self-administered online dietary assessments for adults

Running Title: Development of portion size photographs

Original research

Yasmine Probst NHMRC Research Fellow, PhD[1]*,

Holley Jones Associate Research Fellow, BND[1],

Gemma Sampson Research student, BND[1], Kimberley Smith Research Student, BSc[1]

[1]Smart Foods Centre, University of Wollongong, Wollongong New South Wales 2522, Australia

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* Corresponding author

Yasmine Probst Smart Foods Centre, University of Wollongong, Wollongong New South Wales 2522 Australia, Phone: +612 4221 5302, Fax: +612 4221 4844, Email: yasmine@uow.edu.au

Key words: portion size, Australia, Internet

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Introduction

Dietary assessment is largely moving to utilise technology, with many forms of assessment now automated through specifically designed software packages or use of the Internet, PDA or Smartphones.[1] Such technology allows an assessment to be streamlined, reach a wider number of users and improve time efficiencies for the Dietitian and/or researcher.[2] The DietAdvice website is one example of such technology. This website utilises self-administered dietary assessment and encompasses methodologies from both the diet history interview and food frequency questionnaire.[3-4] DietAdvice was developed for adults and trialled in the primary healthcare[5] and clinical research settings[6] by Australian adults. Users reported their dietary intake through the website. The food data can be accessed remotely by a Dietitian for development of individualised dietary advice. This automated process enables more emphasis to be placed upon dietary analysis and individualised dietary counselling.[5] The trials to date have found that the privacy and anonymity of the DietAdvice website had the potential to improve the accuracy of reporting by removing the bias that may be seen in the face-to-face setting.[7] This anonymity may also encourage the reporting of the portion size actually consumed.[8]

The use of food portion size photographs have long been shown to enhance the accuracy of dietary reporting.[9-11] Current food portion photographs in the DietAdvice website were well received by website users and have been reported to be more useful than text-only portion sizing.[5] These portion size images, however, were only available for research purposes and were not developed using Australian food items. Recommendations were also made in previous studies to clarify food portion sizes by comparing them to a standard of reference.[12]

This would allow users to better interpret the amount shown, as life-sized images are unable to be displayed on screen.

Each individual has their own perceptions about the amount of food in a 'standard' portion, adding much confusion to serving sizes and their use[13] There are several methods commonly used by Dietitians to assess dietary intake of their patients including food records, 24-hour recalls[14] and diet history interviews.[15] Food portion photography can be incorporated into each of these methods, though is most commonly found in the diet history interview or 24-hour recall. Food portion photographs are generally required for food groups in several sizes to represent the range of portion sizes consumed e.g. small medium and large or ¼ cup, ½ cup, 1 cup[16] in , either a printed or an electronic version. The electronic method is appealing as they are easily transported by the interviewer or Dietitian, emailed or posted on websites.[11]

Commercially available food portion photographs are limited in Australia. Available resources either include singular food items in their 'recommended' serving sizes or contain a limited range of foods overall. Graduated food portion images allow for a range of images to be shown to a client or patient and for them to select the image closest to the amount they consume. Studies have shown the use of a larger amount of images also improves the accuracy of estimates.[17] Due to their limited availability in Australia, to date Dietitians have been required to utilise dated print resources from overseas such as those from the UK[18] or Europe.[19]

The use of food photographs relies on how able and willing participants are to remember and accurately estimate the amount of food consumed.[9] Assessing food portion sizes from

photographs is dependent on perception, conceptualisation and memory.[20] Perception is the ability to relate the amount of food which is present in reality to the amount depicted in the photograph. Conceptualisation is the ability to develop a mental picture of portion of food not actually present and to relate this picture to a photograph. Memory is the ability to accurately recall the amount of food eaten, affecting the accuracy of conceptualisation. Persons attending school compared with those not attending school, were 1.92 times more likely to choose the correct portion size photograph.[21] This suggests that the level of education may also improve conceptualisation and memory performance. Furthermore, adults underestimated the amount of food they had eaten by 5% ($p=0.182$) after being shown photographs within 5 minutes of consuming the food, indicating that the timing may also be important.[10]

Portion size estimation also appears to be influenced by factors such as body mass index and level of satiety of the person while selecting the portion. In a study of 47 adults, where 25 (53%) were classed as overweight, significant differences of estimation portion size weights were found for photographs of cheese, chips, mashed potato, rice, spaghetti and sausage rolls both immediately and 3-4 days after exposure to the food. A tendency to overestimate was also found.[22] A body mass index greater than 30kg/m^2 was associated with an 8% underestimation of the food portion size.[23] Meat, fats, sweets and alcohol consumption are most typically underreported.[13] This further emphasises the impact of perception on the outcomes of food photograph use.

The use of digital food portion photography has been described and validated in a number of studies.[9, 11, 20, 24] The use of digital food portions in an electronic medium, such as the DietAdvice website, has been reported less frequently. Many studies utilise short time periods

between the exposure to, or consumption of a food item and the assessment of the amount using portion sizes. In an electronic format, food portion images are most frequently related to 24-hour recall assessments or food records. No studies were retrieved addressing dietary assessment forms requiring long-term memory, such as the diet history interview. This paper describes the development of digitally photographed food portion images for an electronic medium for dietary assessment. This assessment utilises a 7-28 day usual intake period of intake. The methodology can be applied to the development of other technologies for dietary assessment or similarly duplicated for production of hardcopy printed resources.

Methods

Foods contained in the DietAdvice website database[4] were assessed individually to determine the number of foods requiring portion images to assist with dietary intake reporting. Foods were determined to not require an image if they were similar to another food i.e. different images could be used such as for mashed potato and pumpkin. Non-perishable foods were purchased the week prior to photography, in accordance with the prepared budget. Perishable foods were purchased the day prior to photography to ensure freshness and quality of appearance. Wherever possible, foods were cooked or prepared in advance to minimise time delays. For example dry foods such as sugar and rice were pre-portioned and stored in airtight bags and containers to maximise the photography time and minimise time-losses caused by food preparation. Portions were weighed by Dietitians and Nutrition researchers with a precision error of 5g using digital kitchen scales (CAS Corporation SW-1, 2002. minimum 20g, maximum 2kg, e=d=1g, T=-2.0001g). Standard cup, teaspoon and tablespoon measurements were taken with a level surface.

Foods were placed and photographed on a standard 25.40cm (10 inch) diameter white dinner plate with a dinner knife to the right of the plate and dinner fork to the left.[25] Other foods were placed in a standard 15.24cm (6 inch) white bowl with a dessert spoon placed to the left of the bowl. The crockery and cutlery served as standard of reference for each frame. Beverages were photographed in a central position using standard glassware and crockery such as wine glasses (150 ml and 200mL), beer glasses (285ml, 375mL and 425mL), a white tea cup (180 ml) or a white mug (240 ml).

Foods were photographed using a digital Canon EOS 1D mark II camera mounted on a tripod with a Canon EF 100mm f2.8 macro lens. Lighting was provided by three Canon strobe units, (2x 550EX, 1x 580EX). One strobe (580EX) was mounted on camera hotshoe as master, and two slave units (550EX). All strobes were bounced off a white ceiling. The camera was tripod mounted (Manfrotto 055) and the slave strobes mounted on light stands (Manfrotto 052). Food photographs are generally taken in daylight to ensure the foods appearance is natural. Some photographers also recommend that fluorescent lighting should be avoided in food photography. However, this lighting was unavoidable in the current study. To overcome the fluorescence, multiple flashes were used that fired simultaneously and bounced off the ceiling, creating a triangle with the food in the centre. This provided an even blanket of light with minimal shadows on the food or plate.

Photographs were taken from above the food with a 45º angle to show both the depth and height of the foods. Matt, white cardboard was used for the background and marked with regions for placement of the crockery to maintain consistent alignment throughout the photographs. The tripod was also fixed in position for the duration of photography. The white cardboard background was curved against the wall to avoid any join creases and ensure the

food was the focus of the frame. All foods were photographed from the same angle and distance so that the apparent size of the foods remained consistent throughout. Each set up was bracketed ± between one third or two thirds of a stop (i.e. 3 or 4 shots of each setup were taken with a changing aperture between each frame) to achieve the correct exposure. The shutter speed was set to two seconds with an aperture between f13 and f22 and an ISO of 400. The shutter was released using two second self-timer to avoid camera shake.

Results

One to eight portions were prepared for each food to create a series of photographs with various weights and sizes including extra small, to extra large. Most extra small and extra large sizes were seen as outliers, being too small or large to have as a meal. The sizes were selected to portray a graduated increase in portion using an average size (medium) selected from FoodWorks nutrition analysis software (v5, 2007, Xyris Pty Ltd, Highgate hill, QLD), AUSNUT 2001 database[26] for most foods. The smaller and larger sizes of these foods were then determined based on other FoodWorks sizes, typical availability in packages and common amounts consumed from clinical research studies. The number of portions prepared was specific to each individual food item though ensured that common measures were addressed. Many foods, if shown in a one cup portion were then also shown as ½, 1/3 and ¼ cup for consistency. Packaged foods were removed from their containers wherever possible and packing was recreated to remove any visible branding.

Food positioning on the plate or bowl was important to allow the user to see the majority of the food and its contents without compromising aesthetic appeal. In all photographs, foods were placed in the same position. Where required the contents of foods such as a burrito with

its filling was placed facing the camera. All images were adjusted to 150pixels, 72dpi to allow them to be uploaded to the website. The photos were then sorted to determine the most appropriate exposure for each food.

Discussion

The food items varied from single foods through to cooked dishes, condiments and beverages. It was determined that approximately 200 food items from the website required images, with varying portion sizes ranging from two (spirits) to eight (canned fish) images per food item (Table 1). Some foods with singular portion sizes were not photographed due to time limitations. A total of 631 images were required with a mean of four different portion sizes per food item. All foods were photographed over a period of four days.

Table 1: Weight of the portion size depicted for selected sample food types

Food item	**Depicted weight (g)**					
Rice (plain)	20 (Tbsp)	60 (1/3 cup)	90 (1/2 cup)	180 (1 cup)		
Fish	65	95	150	200	285	385
Quiche	58	122	174	264		
Brownies	80	110	175	215	271	
Muffin	55	80	147	170		
Steak	80	130	185	280	345	
Potato crisps	50	100	200	250		

The art of photographing food portions is a difficult task when considering the specifications required. Inappropriate angles or lighting can make the food appear larger or smaller than it actually is. Timing is critical as the food can melt, wilt, collapse or discolour if the photo is not taken promptly. Food such as ice-cream, burritos and fruit needed to be photographed quickly to prevent deterioration and ensure a quality real-to-life photographs.

Clear labelling and a standard of reference for all photographs was necessary.[5] Studies have shown that older participants prefer food photographs for estimating portion sizes, particularly when the picture is a "representative" of the food instead of what was actually consumed[27] or when the portion sizes can be increased and decreased on a plate.[5] In response to the confusion that some participants may experience when a food is displayed without measuring tools, the photographs for the website were taken of standard sizes (teaspoon, tablespoon, ¼ cup, 1/3 cup, ½ cup, ¾ cup, 1 cup) and of foods when spread out on a plate, to enable visualisation of portions as they would be eaten in the home (Fig. 1 and 2).

Use of a series of up to eight photographs is associated with relatively small errors in portion size perception when compared with a single average portion photographs which are associated with substantial underestimation[17, 20] A series of photographs can also increase the accuracy of food frequency questionnaires particularly when referenced on a plate[20]

Estimation errors increase when food photographs differ from the foods that are eaten and consumed. When served foods were different to the photograph in terms of portion size, type of food or both, correct estimation of food portions was reduced from 82% to 48%.[28] Large variability was found for estimation error at the individual level , however, at a group level the error was generally less than one photograph from the correct portion photograph.[28]

Perceived portion size estimates for individual foods had a weight range difference from 9g to 32g which equated to energy intake differences of between 20kJ to 305kJ; where a 10g difference in a cheesecake portion size relates to an energy intake difference of 120kJ.[8, 21]

In addition to energy intake differences, other nutritional components of a food could also be substantially affected. An incorrect photograph of mixed vegetables would have a small energy intake difference of 81kJ, but a large β-carotene difference of 1073μg highlighting the nutritional importance of estimating portions correctly.

Figure 1: Example of the food photograph series used for green peas shown on a standard white dinner place with the knife and fork as a standard of reference

1 tablespoon ¼ Cup

1/3 Cup ½ Cup

¾ Cup 1 Cup

Subsequently, this research team attempted to produce as many photographs of individual foods as possible. However, where foods were similar, photographs were used in the website to represent a group of foods instead of the individual food e.g. meat with sauce rather than meat with each specific type of sauce.

Figure 2: Example of the food photograph series used for muesli shown in a standard white bowl with the spoon as a standard of reference

¼ Cup ½ Cup

1 Cup

There is no known agreement on the degree of influence that food shape has on the ability to estimate food portion size from photographs[21] though slightly less error has been determined for solid foods than amorphous or liquid foods.

Photographs can be limited by the cost of production, number of foods photographed and portability. Life-sized pictures are said to provide more accurate results[29] though uploading life-sized photographs on to the DietAdvice website would be impractical due to memory

size and variability of screen sizes and Internet connection speeds. In an electronic format, larger images are seen to be less accurate when used for estimation.[17]

The most accepted method of photographing food portions includes the use of a 45 degree angle [17, 25], as was used in this study. Although the research team did not attempt to validate the images as part of this work, studies have shown the angled portion photographs of electronic images resulted in the most accuracy when estimating portion sizes.[17]

The research team found difficulties with some food types that are not customarily eaten out of a bowl or from a plate with a spoon, knife or fork. For example nuts were photographed in a bowl with a spoon beside whilst many people would them in small handfuls. This may also be a limiting factor when it comes to users determining their portion. The depth of foods such as mayonnaise in a white bowl also created a challenge, however, this could only have been addressed by changing the camera angle to produce more depth of the food,[20] a process which would have affected the standardisation of the images.

The development of food portion photographs adds relevance to the portion identification component automated dietary assessments, due to the use of country-specific food items such as Vegemite on toast. The portion images should also help users to visualise the amount of food that they consume and assist with memory recall. As the portion images are available on screen, the validity of these portion images will need to be tested to determine whether the user is able to relate to the smaller image with a standard of reference included in it. Although the present images utilise the crockery and cutlery as the standard of reference, future research will need to determine whether the variability of these items will require the addition of a ruler or similar reference to the images. This future research will also compare the

images in both their electronic and hardcopy format with pre-weighed food portions to determine the accuracy of reporting using the two different media utilising the concepts of perception, conceptualisation and memory.

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